INHERITANCE OF RESISTANCE TO ANTHRACNOSE IN WATERMELON

by

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INTRODUCTION

Anthracnose caused by the fungus Colletotrichum lagenarium (Pass.) Ell. & Halst. was reported as early as 1875 on watermelon, Citrillus vulgaris Schrad. by Passerini in Italy. It was first reported in the U. S. A. by Scribner in 1888. However, at this time there was no report of any varietal resistance to the disease.

The first report of a major watermelon disease being controlled by resistant varieties was in 1907 when Orton (12) released the variety Conqueror, which was resistant to Fusarium wilt caused by the fungus Fusarium oxysporum f. niveum (E. F. Sm.) Snyder & Hansen. Following this many watermelon breeders were attempting to develop new varieties which were resistant to the pathogenic fungus and neglecting the improvement of horticultural qualities. Failure of wilt resistance to be associated with the ideal horticultural characters discouraged the growers from planting the new varieties that were developed.

Now it is recognized that anthracnose is the most destructive watermelon disease in the United States of America. Recently developed anthracnose resistant varieties have brought new hope to the watermelon industry. There are approximately one-third of a million acres[1] of watermelons grown in the U. S. A. annually and the average loss to growers by anthracnose alone is roughly estimated by S. P. Doolittle[2] as three-million dollars, but in severe cases it may go up to 10 million dollars. The disease is most destructive in the southeastern states, but heavy losses have also been recorded in Kansas

1 Personal letter from D. A. Kaple of Editorial Department, "American Vegetable Growers", Willoughby, Ohio.

2 Personal letter from S. P. Doolittle, Principal Pathologist, U. S. D. A. Plant Industry Station, Maryland.

(PLATE I) and most Kansas growers now recognize the need for anthracnose resistant varieties.

The fungus attacks all above ground parts of watermelon plants including leaves, petioles, stems and fruits in all stages of development (PLATE II). In severe cases melon fields may look as if they had been "burned over". Anthracnose causes heavier losses to watermelons in transit than any other disease.

Cultural and chemical measures for controlling anthracnose are only adjuncts to the fundamental solution of the problem, the breeding for resistant varieties. At present many vegetable breeders in the U. S. A. are conducting research to develop anthracnose resistant watermelon varieties with good horticultural qualities. But no conclusive published reports are available regarding mode of inheritance of resistance to anthracnose in watermelons. Recent report regarding the existance of different physiological races of the fungus C. lagenarium have further complicated the present knowledge regarding the inheritance of resistance to this disease. Hence such an investigation is of fundamental importance to a practical breeding program.

A genetic study was organized at Kansas State College to determine the relative degree of resistance and mode of inheritance of five commercial watermelon varieties, Congo, Black Diamond, Chris Cross, Fairfax and Charleston Gray. This thesis is based upon a portion of the study.

REVIEW OF LITERATURE

Anthracnose was first observed authentically by Passerini in 1867 on fruits of bottle gourd, Lagenaria vulgaris at Padua, Italy. Eight years later, he reported its extensive occurence on watermelons and cantaloupes (PLATE III).

EXPLANATION OF PLATE I

Anthracnose in a Kansas watermelon field with Charleston Gray, a resistant variety, on the left and Black Diamond, a susceptible variety on the right.

PLATE I

EXPLANATION OF PLATE II

Black Diamond watermelon fruits showing anthracnose lesions.

PLATE II

EXPLANATION OF PLATE III

Fig. 1. Muskmelon fruit showing anthracnose lesions.

Fig. 2. Cucumber fruits showing anthracnose lesions.

PLATE III

Fig. 1

Fig. 2

In 1871 Berkeley (2) called attention to a disease of melons attributable to the fungus, genus Gloeosporium, which he believed might be of great consequence if it were to spread widely.

Scribner (17) was the first to make a detailed report on anthracnose in the U. S. A. in 1888. Soon after his report the disease received considerable attention from many mycologists and plant pathologists of the U. S. A., as a result of which diverse names were given to the same causal organism. Later on, it was generally agreed that the several descriptions applied to the same fungus.

In 1918, Gardner (6) published an excellent review of literature of this fungus and submitted a detailed report along with good illustrations on the dissemination, overwintering and nutritional requirements of the parasite as well as chemical control measures.

Layton (9) made a detailed report on this fungus in 1937. He gave a comprehensive report regarding host range and ecology of the fungus, sources of anthracnose resistance and the genetic behaviour of watermelon varieties resistant and susceptible to anthracnose. According to him a temperature range of 20 to 30°C. is most favorable for infection. He showed that a single factor pair of genes in watermelon govern the inheritance of resistance to anthracnose.

Layton's work is remarkable in the sense that the majority of the present commercial varieties resistant to anthracnose have as a parent Layton's African 8[1] selection. However, Andrus receives the credit for releasing most of the present commercial varieties of watermelons that are resistant to anthracnose combined with good horticultural qualities.

1 Personal letter from J. Robert Wall, Geneticist, Southeastern Vegetable Breeding Laboratory, Charleston, S. C.

In 1947, Dolan (4) questioned Layton's findings. Boothroyd later found that Dolan was not working with anthracnose but another fungus. This information was supplied by Boothroyd to Kalia (8) through a personal letter and is unpublished.

Much literature is available on the breeding techniques and factors governing development and inheritance of morphological characters of watermelon. Rosa (16) has shown that monoeciousness is dominant over the androemonoecious condition and is governed by a single factor pair of genes. Porter (14, 15) discussed among other factors the pollination technique, fruit setting tendency and inheritance of fruit and seed characters. Mann (10) reported on the effect of placement of pollen on stigma in relation to the development of fruit shape. Crossan and Lloyd (3) described a method of artificial field inoculations with spores of C. lagenarium as an aid for creating epiphytotics in the field. Parris (13) gave a good review of work done on breeding techniques. Recently successful research has been conducted in Russia, Japan and the U. S. A. in an attempt to artificially change the sexual characters of cucurbits.

Since publication in 1949 by Parris, a number of other workers discussed watermelon breeding and sources of anthracnose resistant genes. Walker (19) agreed with Layton's results and mentioned Congo and Black Kleckley as two watermelon varieties highly resistant to anthracnose. Munger and Newhall (11) also listed Congo as a source resistant genes, but they advocated moderately resistant foreign plant introductions, in order to synthesize resistance by recombining genes from different varieties with partial resistance.

In the same year Andrus (1) evaluated the use of disease resistance in watermelons. He placed emphasis on the correct diagnosis, the farmer's needs

and pointed out that anthracnose resistance produced a greater benefit to farmers than wilt resistance. He also discussed the methods of testing for disease resistance and recommended a uniform rating chart for the cooperative appraisal of foreign vegetable accessions. According to him one of the best sources of resistant parents may be the centers of early cultivation of watermelons.

In recent years plant pathologists have discovered different physiological races of Colletotrichum species. Summers (18) reported existence of different physiological races of C. hibisci on kenaf. Presence of different physiological races of C. lindemuthianum, the causal organism of anthracnose in bean was reported by Yerkes and Ortiz (20) in 1956.

In January 1957, Goode and Winstead (7) reported that there were three or more physiological races of C. lagenarium. They used five watermelon varieties, New Hampshire Midget, Garrison, Congo, Fairfax and Charleston Gray for their study. According to their report the watermelon varieties Congo, Fairfax and Charleston Gray were moderately resistant to isolates of group 1, very susceptible to group 2, and highly resistant to isolates of group 3. All isolates caused severe infection on plants and fruits of the varieties New Hampshire Midget and Garrison.

MATERIALS AND METHODS

A series of experiments were initiated at Kansas State College in February 1957 as a continuation of the preliminary studies made by Kalia (8) in 1956. The preliminary work consisted of the screening of seedlings of five watermelon varieties and hybrids of crosses between the resistant and susceptible varieties for resistance to anthracnose isolates, C. lagenarium from Georgia, Wisconsin and Arkansas. In these experiments seedlings of the first

and second generations were screened to determine the manner of inheritance of resistance.

Experiments were conducted in the horticultural greenhouse and consisted of:

I. Study of the comparative virulence of the isolates from Kansas and Georgia.

II. Study of the first generation seedlings of a cross between the variety Black Diamond and Charleston Gray.

III. Study of the first generation seedlings of crosses between the resistant varieties Congo, Fairfax and Charleston Gray.

IV. Study of second generation seedlings of F_1 selfed plants.

V. Study of backcrosses with the susceptible parent, Black Diamond.

VI. Study of backcrosses with resistant parents, as mentioned in experiment No. II.

During the spring of 1957 the above mentioned watermelon varieties and their F_1 hybrids were grown in the horticultural greenhouse, but insufficient seeds were produced to make a valid test. So they were all grown again, during the summer of 1957, at the Ashland Horticultural Farm and sufficient crossed and inbred seeds were obtained for conducting all of the above experiments.

Seedlings of all the hybrids, F_2 generations and backcrosses were grown in the horticultural greenhouse and screened for resistance to isolates of C. lagenarium from Kansas and Georgia. Cultures of the fungus were produced in the Mycological Laboratory, Department of Botany and Plant Pathology.

Plant Materials Screened

Seeds of the five varieties, Charleston Gray, Congo, Fairfax, Chris Cross and Black Diamond were obtained from Wilhite Melon Seed Farm, Poolville, Texas, in 1956. The inbred seeds used in these experiments were obtained from them by selfing. Regular routine procedures as described by Rosa (16) and Porter (14) were followed in crossing. Descriptions of different parents and hybrids used for screening follow:

Table 1. Names and pedigree of different parents and crosses.

Name		Pedigree
Resistant Parents:		
1. Charleston Gray		(African 8 x Iowa Belle) x Garrison 2 X (Hawkesbury x Leesburg) x Garrison.
2. Congo		(African 8 x Iowa Belle) x Garrison.
3. Fairfax		Garrison x (African 8 x Iowa Belle) X (Leesburg x Hawkesbury).
Susceptible Parents:		
4. Black Diamond		Originator is not known. Only information available is that it is a selection out of the old Florida Giant variety.
5. Chris Cross		It was introduced by a private breeder, Chris Christensen of Montrose, Iowa in 1956.
Crosses:		
1. F_1 hybrids	(Expt. III)	Charleston Gray x Congo.
2. "	"	Congo x Fairfax.
3. "	"	Fairfax x Charleston Gray.
4. "	(Expt. II)	Black Diamond x Charleston Gray.
5. F_2 hybrids	(Expt. IV)	Black Diamond x Congo – Selfs.
6. "	"	Fairfax x Black Diamond – Selfs.
7. Backcross	(Expt. V)	(Black Diamond x Congo) x Black Diamond.
8. "	"	(Fairfax x Black Diamond) x Black Diamond.
9. "	(Expt. VI)	(Black Diamond x Congo) x Congo.
10. "	"	(Fairfax x Black Diamond) x Fairfax.

Greenhouse Techniques

Soil Preparation and Sterilization. Field soil was obtained from the Ashland Horticultural Farm and mixed with peat moss. The soil mixture was then placed in two-inch clay pots and thoroughly moistened before being steam sterilized. Steam sterilization was done at 210°F. under seven pounds pressure for one hour. No planting was done until four days after sterilization.

Design of Experiments. Every attempt was made to give similar conditions to all experiments. Each pot was numbered serially and placed at random within the same experiment in order to reduce the sampling error. Both susceptible and resistant parents were used in all the experiments as check. Sufficient pots were arranged in each experiment to give about 200 seedlings of each cross and at least 20 of each parent.

Planting Technique. Sterile techniques were used in each experiment to reduce contamination of seeds. Except for experiment No. I, all seeds were treated with 50 percent arasan powder at the rate of one third teaspoonful per pound of seeds. The hybrid seeds used in experiment No. I were soaked for five minutes in a 1/1000 mercuric chloride solution to remove seedborne spores. The benches were washed with same solution of mercuric chloride before placing the pots on them. The parental seeds used in experiment No. I were already treated with arasan by the seed companies.

Four to five seeds were then planted in each pot, to a depth of about one half inch and all pots were watered regularly to obtain germination uniformly. Seedlings were ready for inoculation at 14 days after planting.

Pathogen

Cultures of Fungus. Two isolates, one from Kansas and another from Georgia were used in these experiments. Isolates were maintained on potato

dextrose agar in the Mycology laboratory of Kansas State College and multiplied in test tubes containing frozen bean sections. Approximately 200 test tubes were required to produce sufficient spores for about 2000 seedlings. The green bean sections were sterilized in an autoclave for 20 minutes, at 15 pounds pressure before being inoculated. After sterilization, test tubes were kept for forty eight hours to see if there was any contaimination in the bean sections. The bean sections were then inoculated with isolates of C. lagenarium and incubated at a temperature of between 70 and 75°F. for five days.

After five days typical pinkish spore masses covered the bean sections. Then the bean pieces were placed in about an equal volume of water and ground for one minute with a Waring blender. The mixture was then filtered through cheese cloth and a clear spore suspension was diluted to double the volume in order to make sufficient inoculum. At this stage a small droplet of this suspension was examined under a microscope to check the spore concentration. This stock suspension was divided into several equal parts for each experiment as necessitated, and each part was then diluted to provide a sufficient volume of water, so that seedlings could be dunked into the spore suspension.

Method of Inoculation and Incubation. Seedlings were inoculated with a spore suspension by a simple and satisfactory method called the "dunking technique", which is the standard method used by most workers (PLATE IV). Pots bearing the seedlings were inverted and dipped in the spore suspension. Check plants were also similarly dipped in distilled water in order to maintain uniformity of technique.

Inoculations were made in the propagation chamber of the horticultural greenhouse where the temperature was maintained between 70 and 95°F. and a

EXPLANATION OF PLATE IV

Inoculation of watermelon seedlings by the "dunking technique".

PLATE IV

high humidity was maintained by means of mist nozzles.

With these methods, the disease symptoms were visible at about five days but were not sufficiently diveloped for taking final records until nine days after inoculation.

Descriptions of Experiments

Experiment No. I. This was a preliminary experiment to determine the comparative virulence of isolates from Kansas and Georgia and to select the proper isolate for screening in subsequent experiments. Hybrid seeds of the cross between two susceptible varieties, Black Daimond and Chris Cross, were planted on July 10, 1957 and seedlings were inoculated on July 24 from a 5-day old culture. Readings were taken on July 30 and August 3, 1957 respectively and results are reported in Table 2.

Experiment No. II. First generation hybrid seeds of 1957 and those collected by Kalia in 1956 (8) were planted on September 15, 1957, along with the seeds of their parents, in 70 pots arranged at random. The following numbers of seedlings were obtained:

Black Diamond	11
Charleston Gray	15
Black Diamond x Charleston Gray (1956)	53
Black Diamond x Charleston Gray (1957)	65
Charleston Gray x Black Diamond (1957)	102

Seedlings were inoculated on October 1 and records were taken on October 15, 1957. Results are reported in Table 3.

Experiment No. III. First generation hybrid seeds of the crosses between the three resistant parents Congo, Fairfax and Charleston Gray were planted

on August 21, along with their parents, in 143 pots. The following numbers of seedlings were obtained:

Congo	20
Fairfax	24
Charleston Gray	23
Congo x Fairfax	223
Charleston Gray x Congo	166
Fairfax x Charleston Gray	158

Inoculations were made on September 4, and records were taken on September 13, 1957. Results are recorded in Table 4.

<u>Experiment No. IV</u>. Selfed seeds of crosses 5 and 6, along with their parents, Black Diamond, Congo and Fairfax, were planted in two installments, one on August 20 and the other on September 15, in order to get a sufficient number of seedlings. The following total numbers of seedlings were obtained:

Black Diamond	34
Congo	35
Fairfax	40
Black Diamond x Congo (selfed)	186
Fairfax x Black Diamond (selfed)	274

They were inoculated on September 2 and October 1 respectively. Readings were taken on September 12 and October 15 and results are reported in Table 5.

<u>Experiment No. V</u>. Backcrossed seeds of crosses number 7 and 8 of Table 1 and their parents were grown in 175 pots, in three installments. The following numbers of seedlings were obtained:

Black Diamond	50
Congo	46

Fairfax 43

(Black Diamond x Congo) x Black Diamond 300

(Fairfax x Black Diamond) x Black Diamond 366

Plantings were made on July 7, August 20 and September 15. The seedlings were inoculated on July 24, September 2 and October 1 respectively. Readings were taken on August 6, September 12 and October 13 respectively and results are reported in Table 6.

Experiment No. VI. Backcrossed seeds of crosses 9 and 10 and their parents were planted in 103 pots on August 20. The following numbers of seedlings were obtained:

Black Diamond 30

Congo 25

Fairfax 25

(Black Diamond x Congo) x Congo 120

(Fairfax x Black Diamond) x Fairfax 134

Seedlings were inoculated on September 4 and readings were taken on September 13, 1957. Results are reported in Table 7.

Techniques of Evaluation

Clear symptoms appeared five to six days after inoculation when the temperature of the propagation chamber varied between 70 to 95°F. but during the month of October when the temperature varied between 65 to 80°F. clear symptoms did not appear before 10 to 12 days after inoculation. Therefore, readings were taken as and when required. A brief description of the infection rating system that was used in these experiments is outlined below, and are shown in PLATE V.

EXPLANATION OF PLATE V

The infection rating system that was used in all experiments.

PLATE V

Degree of infection	Rating of types	Description of Symptoms
Immune	0	No infection, characterized by absence of symptoms of the disease.
Very resistant	1	Slight infection, characterized by a few spots or lesions on any above ground plant parts.
Moderately resistant	2	Medium infection, characterized by some lesions on any above ground plant parts.
Mixed doubtful	3	Comparatively severe infection but plants were alive.
Moderately susceptible	4	Very severe infection characterized by prostation of plant.
Completely susceptible	5	Death of the plant due to injury.

As soon as symptoms appeared on the seedlings, individual plants were inspected and rated by the above key. The degree of infection was averaged for each variety and date of inspection, and then as overall mean was calculated for each treatment or variety for each date. Two to three observations were made at suitable intervals for each experiment. For all practical purposes, seedlings showing a degree of infection of more than 2.50 were regarded as susceptible and seedlings having a degree of infection of equal to or less than 2.50 were regarded as fairly resistant.

EXPERIMENTAL RESULTS

Seedling Reaction to Two Isolates of C. lagenarium

Two isolates of C. lagenarium, one from Kansas and the other from Georgia, were tested and the results are given in Table 2.

Table 2. Mean degrees of infection at 3, 6 and 9 days after inoculation.

Name of isolate	Number of seedlings (N)	3 days	6 days	9 days	Mean of last two observations
Kansas	23	0.08	2.60	4.20	3.50
Georgia	27	2.40	3.80	5.00	4.40

The calculated value of "t" was 22.1 with "P" much less than 0.01, showing that the difference of the means were significant at the one percent level.

The Georgia isolate was found to be significantly more virulent than the Kansas isolate, especially in the early stage of infection, but after nine days the Kansas isolate also was found to be very pathogenic to watermelon seedlings.

Since the Kansas isolate was obtained locally and was pathogenic, it was used in all the subsequent experiments as a standard.

Study of the First Generation From the Cross Between Black Diamond and Charleston Gray

The variety Black Diamond was found to be susceptible and Charleston Gray was resistant. Results of their reciprocal crosses made in 1957 are given in Table 3 along with those obtained in 1956.

Seedlings of the variety Charleston Gray and those of the 1957 hybrids, all were found to be resistant and their resistance was significantly different from those of Black Diamond and of the 1956 hybrid.

Since Charleston Gray was found to be equally resistant to Congo and Fairfax seedlings, a cross with Black Diamond should be equally resistant to those of the hybrids with the other two resistant parents, because all three

Table 3. Mean seedling infection.

Variety and Cross	Degree of Infection
Black Diamond	4.16
Charleston Gray	0.80
Black Diamond x Charleston Gray (1956)	4.32
Black Diamond x Charleston Gray (1957)	0.88
Charleston Gray x Black Diamond (1957)	0.47
L. S. D. at 5 percent level	0.98

have a common source of resistance. However, in the 1956 experiments the Black Diamond x Charleston Gray hybrid was found to be completely susceptible. It is believed that this was a chance Black Diamond self since the seedlings reacted as such. During 1957 the same hybrid was repeated and compared with the 1956 hybrid. Results are reported in Table 3 and definitely indicate that it was not a true hybrid, but was a Black Diamond self. This was further confirmed by the fact that the fruits obtained from the 1956 hybrid when grown in the field during the summer 1957 were typically Black Diamond.

Study of the First Generation Hybrids From the Crosses Between Charleston Gray, Fairfax and Congo

All three varieties were found to be resistant to anthracnose. The three possible crosses were made between them and compared with each parent for resistance. Results of these experiments are presented in Table 4.

Seedlings of the three varieties and their hybrids were found to have slight differences in resistance but these differences were not significant at the five percent level. This would indicate that all three varieties carry a similar or the same gene for resistance, which was obtained from the

variety African 8, which was selected by Layton (9).

Table 4. Mean seedling infection.

Variety and Hybrids	Degree of Infection
Fairfax	0.60
Congo	0.55
Charleston Gray	0.93
Fairfax x Congo	0.54
Fairfax x Charleston Gray	0.61
Charleston Gray x Congo	0.81
L. S. D. at the 5 percent level	0.71

Study of the Second Generation Seedlings From the 1956 Crosses

Two crosses which were made between the resistant varieties Congo and Fairfax and the susceptible variety Black Diamond in 1956, were grown in the field during 1957 and selfed. The seeds obtained from these selfed fruits planted in the greenhouse as previously described. These second generation seedlings were then inoculated and the infection results are reported in Table 5.

The contingency Chi-Square value shows that the results were not affected materially by conducting the experiments at two different dates and the pooled Chi-Square value confirms that the hypothesis of 3:1 ratio was acceptable.

The acceptance of the 3:1 ratio indicates that the resistance to anthracnose was controlled by one dominant gene. This was further confirmed by the subsequent experiments.

Table 5. Phenotypic classification of seedlings from the F_2 populations.

Cross No.	Date	Resistant	Susceptible	Contingency Chi-Square with 1 d/f	Expected ratio	Pooled Chi-Square with 1 d/f	"P" lies between
5	9.12.57	54	20	2.23	3:1	1.21	Contingency 0.25 to 0.10
	10.12.57	92	20				Pooled 0.50 to 0.25
6	9.12.57	86	32	0.58	3:1	0.006	Contingency 0.50 to 0.90
	10.12.57	120	36				Pooled less than 0.90

Study of Backcrosses With the Susceptible Parent, Black Diamond

The first generation hybrid plants of the crosses as mentioned in the experiment IV, were backcrossed to their susceptible parent, Black Diamond. Seeds obtained out of these backcrossed fruits were planted in pots and seedlings were inoculated. The infection result is given in Table 6. (see also PLATE VI).

In both the backcrosses the "P" values obtained permits acceptance of the hypothetical ratio 1:1. The results obtained here confirm results obtained in experiment IV, and further prove that resistance is controlled by a single gene.

Study of Backcrosses With Resistant Parents

The first generation hybrids of the crosses, Black Diamond x Congo and Fairfax x Black Diamond, were backcrossed to their resistant parents, Congo and Fairfax, respectively. Seedlings of these backcrosses were inoculated and their infection results are given in Table 7.

All seedlings tested were found to be resistant, which agrees quite well with the expected results. This experiment also shows that the gene for resistance was completely dominant over the gene for susceptibility.

DISCUSSION OF RESULTS

Genetically speaking a resistant reaction to anthracnose so far as the Kansas strain is concerned, may be due to the action of a single gene, say "R". This is indicated by the completely dominant reaction in the progenies from the crosses, Black Diamond x Congo and Fairfax x Black Diamond. The single factor mode of inheritance of resistance agrees quite well with the

Table 6. Phenotypic classification of hybrids backcrossed to the susceptible parent, Black Diamond.

Cross No.	Date	Resistant	Susceptible	Contingency Chi-Square with 2 d/f	Expected ratio	Pooled Chi-Square with 1 d/f	"P" lies between
7	8. 6.57 9.12.57 10.13.57	59 30 67	58 35 51	2.10	1:1	0.48	Contingency 0.50 to 0.25 Pooled 0.50 to 0.25
8	8. 6.57 9.12.57 10.13.57	78 30 77	83 34 64	1.58	1:1	0.02	Contingency 0.75 to 0.50 Pooled 0.90 to 0.75

Table 7. Phenotypic reaction of hybrid seedlings resulting from backcrosses to the resistant parents.

Cross No.	Resistant	Susceptible	Expected
9	120	0	1:0
10	134	0	1:0

EXPLANATION OF PLATE VI

Segregation of resistant and susceptible watermelon seedlings in a second generation population.

PLATE VI

findings of Layton (9). No comments can be made regarding their reaction in the segregating progenies of Black Diamond x Charleston Gray.

At present no conclusion can be made regarding the final genotypic constitution of the varieties under study, as far as the resistant reaction is concerned, until these and progenies of the crosses are tested with the physiological races of anthracnose which were discovered by Goode and Winstead (7). However, so far as the Kansas isolate is concerned it can be concluded that the two varieties, Congo and Fairfax, have the genotypes "RR" and Black Diamond "rr". The variety Charleston Gray apparently also has the "RR" genotype as evidenced by experiment III, but final conclusion can be made only after testing progenies of second generation segregating population from the cross between Black Diamond x Charleston Gray.

The discovery of different physiological races of the fungus _C. lagenarium_ by Goode and Winstead (7) is based mainly on their difference in virulence to certain resistant varieties. Moreover, since Layton's time (1937) many vegetable breeders have been working in this field but until 1957 there was no published report regarding the differences of virulence of this pathogen.

All these facts suggest a possibility that there may be some spontaneous mutation of virulence of this fungus similar to those which have been reported by Garber, et al. (5) in radish and turnip varieties. These were discovered while working with some biochemical mutants of a bacterial plant pathogen, _Erwinia aroideae_.

So a further investigation to determine the reason for this difference in virulence of pathogen host relationship between the fungus _C. lagenarium_ and the host watermelon varieties is suggested.

SUMMARY AND CONCLUSION

Inheritance of anthracnose resistance was studied in the segregating populations of the two crosses, Black Diamond x Congo and Fairfax x Black Diamond. Results obtained from selfs and backcrosses indicated that both the varieties, Congo and Fairfax, had one dominant factor for resistance to the Kansas isolate of C. lagenarium. The resistant gene "R" was found to be completely dominant over the recessive gene "r" for susceptibility.

Even though the Kansas isolate lacked the virulence of the Georgia isolate it appeared that all varieties showed the same type of reaction with both of these two isolates. Both Kansas and Georgia isolates were found to be clearly pathogenic but because the Kansas isolate was obtained locally it was used in all screenings.

Results obtained from F_1 seedlings from the cross, Black Diamond x Charleston Gray, in 1957 contradicted the results of the same cross made by Kalia (8) in 1956. It was found that the variety Charleston Gray does not possess the recessive gene for susceptibility. On the basis of these results it is assumed that the cross made in 1956 was a chance self of the female susceptible parent, Black Diamond, rather than a true hybrid and the variety Charleston Gray carries the same "RR" genes for resistance as Congo and Fairfax.

Infection levels up to 2.50 were not considered severe since all seedlings were found to survive the infection.

It was also found that certain environmental factors such as temperature and humidity were important in obtaining proper infection. A temperature range of 70 to 95°F. permitted the pathogen to develop and produce infection symptoms on the seedlings.

The most desirable seedling age for inoculation was found to be 14 days, including three to four days for germination. Five-day-old cultures on green bean sections proved to be most satisfactory for inoculation.

It can be inferred from this series of experiments that so far as the Kansas isolate is concerned, the mode of inheritance of resistance is controlled by a single gene and that resistance is dominant over the susceptibility, as was reported by Layton (9). But, findings here cannot be conclusive until further experiments are conducted with other existing physiological races of _C. lagenarium_, some of which have been reported by Goode and Winstead (7) in 1957.

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INHERITANCE OF RESISTANCE TO ANTHRACNOSE IN WATERMELON

by

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This thesis is based on a portion of the series of studies which are being conducted at the Kansas State College to determine the relative degree of resistance to anthracnose caused by the fungus *Colletotrichum lagenarium* and mode of inheritance of resistance. The five commercial watermelon varieties, Congo, Fairfax, Charleston Gray, Black Diamond and Chris Cross, were evaluated for relative resistance to the pathogen and progenies from the various crosses were studied to determine the mode of inheritance.

Study of the first generation hybrid seedlings of crosses between the susceptible varieties, Black Diamond and Chris Cross and the resistant varieties, Congo, Fairfax and Charleston Gray, indicate that all resistant varieties apparently possess similar genes for their resistance and likewise the susceptible varieties possess similar recessive genes for their susceptible nature.

Testing of second generation segregating populations of inbreds and the backcross seedlings indicated that so far as Kansas isolate is concerned, the mode of inheritance of resistance is governed by a single pair of genes only.

Further investigations are necessary for testing the mode of inheritance to all recently discovered physiological races of the fungus, *C. lagenarium*, before conclusion can be made.